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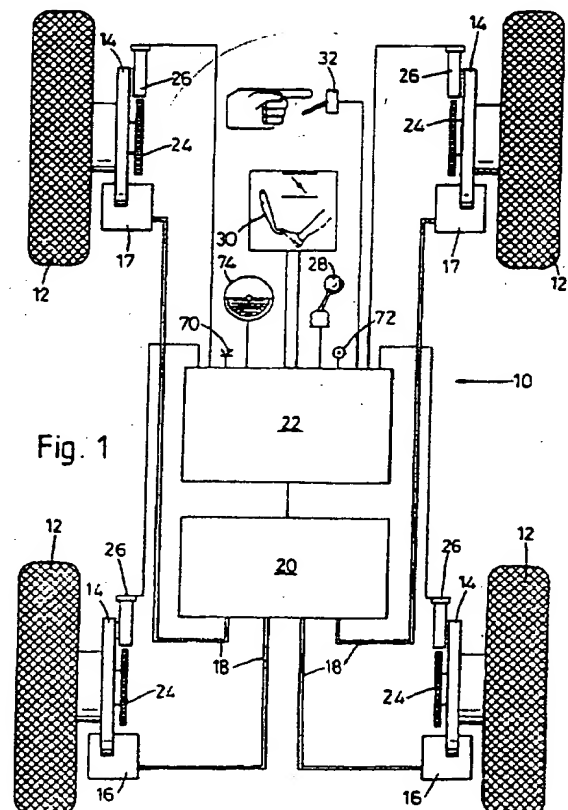
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(54) Abstract Title

Brake control systems for wheeled vehicles

(57) A wheeled vehicle has brakes (14, 16) controlled by an electronic control unit (22) and a hydraulic control system (20). A switch (32) can be used to cause the control unit to enter a hill descent control mode. In this mode the control unit controls the speed of the vehicle by keeping it at or below a threshold level to achieve controlled descent of a hill without the need for the driver to apply the brakes.



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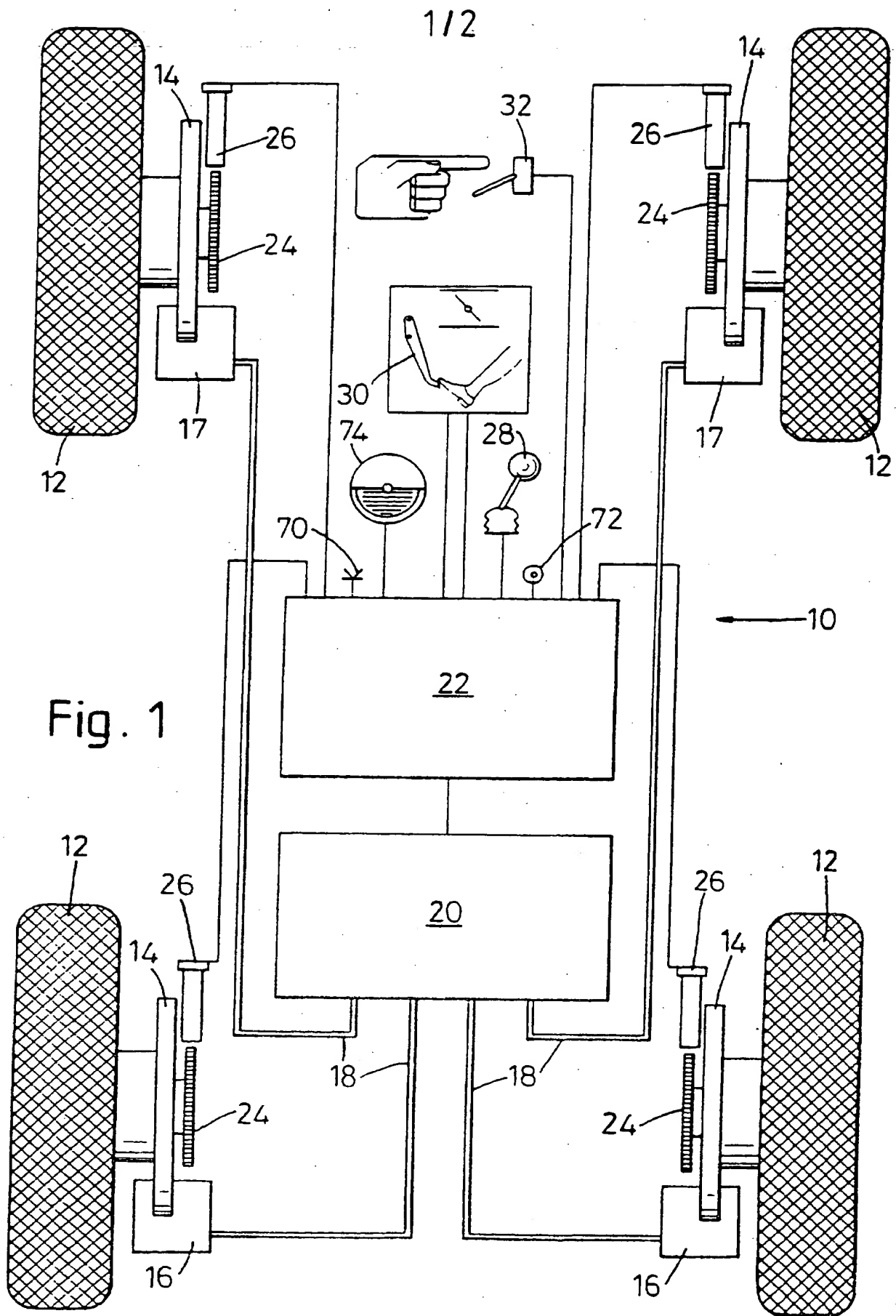
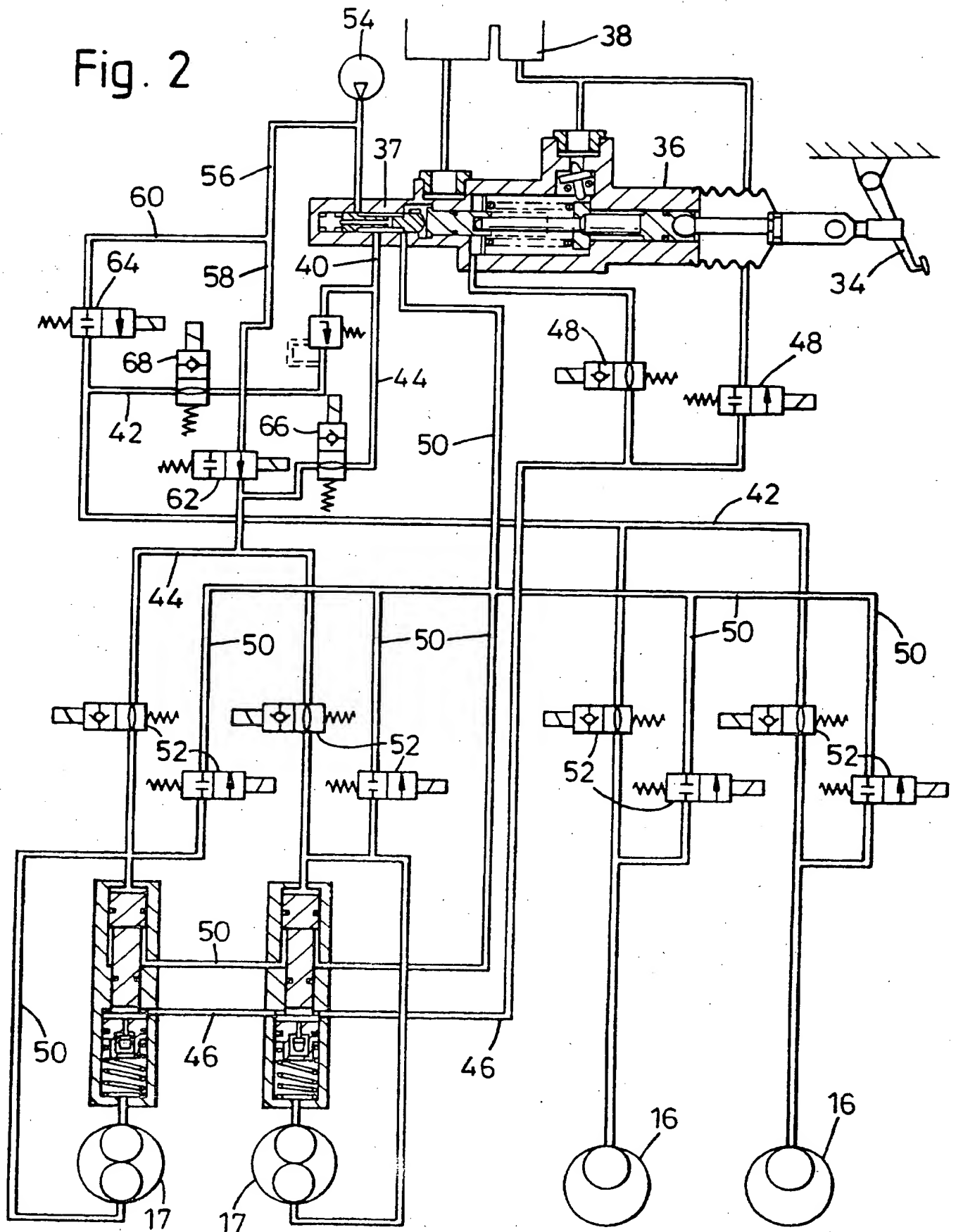


Fig. 1

Fig. 2



A WHEELED VEHICLE

The invention relates to a wheeled vehicle having a braking system, and in particular to the use of the braking system to control the descent of hills by the vehicle. It  
5 is particularly useful for off-road vehicles.

When a wheeled vehicle such as a car is going down a steep slope, it is usual to put the car into a low gear and use engine braking to slow the vehicle. The speed of the vehicle will depend upon the gear selected and the  
10 steepness of the slope. As a result, the brakes may still need to be used from time to time if the slope becomes particularly steep. On very steep slopes engine braking may not be sufficient to allow a controlled descent. In an off road environment slopes are frequently far steeper than  
15 usually encountered and traction can be poor, particularly in wet or muddy conditions.

It is known from DE-A-24 19 242 to provide a braking system wherein the brakes are controlled so that the position of the brake pedal defines exactly the retardation  
20 which will be produced. However, such a system would not be effective in controlling the descent of a hill under conditions of poor traction because, as soon as traction is lost, the speed of the vehicle will change and the system will not be able to return it to a speed suitable for the  
25 conditions.

JP A 61102336 discloses a cruise control system for a vehicle in which the brakes are controlled to limit the vehicle speed to that set by the cruise control system when the vehicle is descending a hill. The system described in  
5 that document includes all the features of the characterising portion of Claim 1. However, that system is not designed or intended for use at high speeds. It would therefore not provide sufficient control in an off-road situation to avoid loss of traction.

10 According to the present invention there is provided a brake control system for a wheeled vehicle having a plurality of wheels, a plurality of braking means each for braking one of said wheels, and wheel lock detection means for detecting locking of any of said wheels, the system  
15 comprising control means which has activated and deactivated states, wherein in its activated state the control means is arranged to apply each braking means to slow the vehicle when a detected vehicle speed is above a predetermined target speed and no wheel locking is  
20 detected, but to release any of the braking means if locking of its respective wheel is detected while the detected vehicle speed is above said target speed and to control the rate of change of speed of the vehicle towards the target speed if the vehicle speed is substantially  
25 different from the target speed.

Preferably, the control means is arranged to apply the braking means when the detected vehicle speed is below the

target speed if necessary to ensure that the rate of acceleration of the vehicle is less than a limit value.

Preferably the control means is arranged, on entering its activated state, to compare the vehicle speed with the target vehicle speed and to control the braking means to bring the vehicle speed towards the target speed.

Preferably the control means in its activated state is arranged to be over-ridden by the operation of a braking demand means of the vehicle by a driver to increase the amount of braking over that provided by the control means to slow the vehicle below the target vehicle speed if no wheel lock is detected. Thus, where braking is required while the control means is activated, the control means need not be de-activated in order for the braking to take full effect.

The control means is preferably arranged to apply the braking means when the detected vehicle speed is below the target vehicle speed if necessary to ensure that the rate of acceleration of the vehicle is less than a limit value. In this way, the target speed can be attained after gentle acceleration without overshoot of the target speed, and a hill can be descended safely and with reasonable rapidity.

Preferably the detected vehicle speed is derived from at least one detected wheel speed. Preferably it is derived from the detected speeds of all of the wheels. However, it

could be determined independently for each of the wheels.  
It is known in anti-lock brake systems to have wheel speed  
detectors, and these can be used to produce a wheel speed  
signal for each of the wheels. They can therefore be used  
5 to determine when one of the wheels has locked.

The present invention further provides a brake control  
system for a wheeled vehicle having a plurality of wheels,  
a plurality of braking means each for braking one of said  
wheels, and wheel lock detected means for detecting locking  
10 of any of said wheels, the system comprising control means  
which has activated and de-activated states, wherein in its  
activated state the control means is arranged to apply each  
braking means to slow the vehicle when a detected vehicle  
speed is above a predetermined target speed and no wheel  
15 locking is detected, but to release any of the braking  
means if locking of its respective wheel is detected while  
the detected vehicle speed is above said target speed,  
wherein the system further comprises sensing means arranged  
to determine the steepness of the slope on which the  
20 vehicle is travelling and the control means is arranged to  
make the target speed dependent on said steepness.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a schematic diagram of the vehicle of the  
5 embodiment; and

Fig. 2 is a diagram of the hydraulic system of the embodiment.

As shown in Fig. 1, the vehicle 10 includes four wheels 12. Each wheel 12 is provided with a co-rotating brake disc 14 which is acted upon by a brake calliper 16. The  
10 brake callipers 16, 17 are hydraulically operated and a hydraulic line 18 leads from each brake calliper to a hydraulic brake control system 20. The hydraulic brake control system 20 is controlled by an electronic control  
15 unit 22.

Each wheel 12 also carries a co-rotating toothed wheel 24. An inductive sensor 26 is provided adjacent each toothed wheel 24 and provides a signal to the electronic control unit 22 in the form of a regular waveform voltage,  
20 the frequency of which is indicative of the wheel speed.

The gear lever 28 is also provided and a sensor is associated with the gear lever 28 and connected to the electronic control unit 22 to send a signal to the



electronic control unit 22 when the vehicle is in first or reverse gear.

The accelerator pedal 30 has a continuously variable sensor in the form of a potentiometer associated with it which provides an analogue signal to the electronic control unit 22 which is dependent upon the position, or angle, of the accelerator pedal.

A manually operable switch 32 is also connected to the electronic control unit 22.

Fig. 2 shows the hydraulic braking system. The brake pedal 34 is connected to a hydraulic master cylinder 36. The master cylinder 36 is fed with hydraulic fluid from a reserve tank 38. An outlet line 40 from a valve 37 in the master cylinder 36 forks into rear and front pressure supply lines 42,44. The rear pressure supply line 42 forks again to supply the rear brake callipers 16 on the left and right rear brakes, and the front pressure supply line 44 also forks again and supplies the left and right front brake callipers 17. A hydrostatic circuit 46 is provided which comprises a line from the front brakes 17 which forks and is connected to opposite sides of the master cylinder 36. Solenoid valves 48 are provided in each branch leading to the master cylinder 36.

Each of the brakes 16 is also connected by a feed/return line 50 to the master cylinder 36. The feed/return lines

50 combine to a single line into the master cylinder 36. A solenoid valve 52 is provided in each of the individual input and return lines 42,44,50. These eight valves 52 form part of the hydraulic control system 20 and are controlled  
5 by the electronic control unit 22 to perform an anti-lock braking function. The anti-lock function is arranged so as always to be in operation. They can therefore reduce the braking pressure to any of the wheels 12 to prevent wheel lock at any time.

10 The system further comprises a pump 54 which supplies brake fluid under pressure to the master cylinder valve 37 and to a pressure supply line 56. The supply line 56 branches into front and rear supply lines 58,60. The front supply line 58 is connected through a front supply valve 62  
15 to front supply line 44. The rear supply line 60 is connected through a rear supply valve 64 to the rear supply line 42.

The front supply line 42 includes a supply/return valve 62 and the rear supply line 60 includes a supply/return  
20 valve 68. These valves can allow pressure to be supplied from the master cylinder valve 37 to the brake callipers, or can allow fluid pressure from the brake callipers to be relieved via the master cylinder valve 37. All of the valves 62, 64, 66, 68 form part of the hydraulic control  
25 system 20 and are controlled by the electronic control unit 22. They enable the control unit to control the brake pressure supplied from the pump 54 to the wheels

independently of the movement of the master cylinder valve 37. They can therefore provide traction control and hill descent control as described in more detail below.

In use, the vehicle is driven normally when the switch 5 32 is switched off. Under these conditions the electronic control unit 22 operates the anti-lock valves 52 to prevent locking of the wheels if the driver brakes using the brake pedal 34. Also traction control is provided by the control unit 22 using the valves 62, 64, 66, 68. Both of these 10 functions are carried out in known manner by monitoring the speed and acceleration of each wheel and a detected vehicle speed calculated from the speeds of all the wheels. The detected vehicle speed is calculated by using an average of all the wheel speeds, but ignoring the speeds of any wheels 15 which are detected as locked or spinning. Locked wheels will be released by releasing braking pressure using the anti-lock valves 52, and spinning wheels will be slowed by applying a braking pressure from the pump 54 using the valves 62, 64.

20 When the activation switch 32 is switched on by the driver to select hill descent mode, the electronic control unit will check from the sensor associated with the gear lever 28 whether the engine is in first gear or reverse gear. If the engine is not in first gear or reverse gear, 25 no action will be taken and the hill descent control will be suspended. If the engine is in first gear or reverse gear, the hill descent control will become active.

If the detected vehicle speed is above a predetermined threshold vehicle speed, the electronic control unit 22 will control the valves 62,64,66,68 as appropriate to control the braking applied by the brakes 16, 17 to bring  
5 the detected vehicle speed down to the threshold vehicle speed and keep it at that speed. This is done by increasing the braking force at a rate which varies with the amount by which the detected vehicle speed exceeds the threshold vehicle speed. Similarly, if the detected vehicle speed is  
10 below the threshold vehicle speed, the braking force is decreased at a rate which varies with the amount by which the detected vehicle speed is less than the threshold vehicle speed. Thus, if the vehicle is on a constant slope, the braking force will tend towards the amount required to  
15 keep the vehicle speed constant at the threshold vehicle speed. If the slope varies the amount of braking will increase or decrease accordingly to maintain the threshold vehicle speed. If the slope decreases enough the braking force will decrease smoothly to zero since no braking will  
20 be required to limit the vehicle speed.

The overall vehicle deceleration rate provided by the hill descent control is limited to a predetermined level of about 0.2 to 0.3 g and preferably about 0.25 g. This is so that, during the period just following the selection of  
25 hill descent mode when the vehicle may be travelling at speeds substantially higher than the threshold speed, the deceleration to the threshold speed will be gentle and

controlled. Similarly, the acceleration of the vehicle up to the threshold vehicle speed under the force of gravity, which is allowed by the control unit 22 releasing the brakes 16, 17, is limited to a predetermined value.

5        If in reducing the speed of the vehicle to the threshold speed, or maintaining it at that speed, a wheel locks, this will be sensed by the electronic control unit 22 as describe above. The valves 52 will be opened to reduce the braking force to the locked wheel under the control of the  
10    electronic control unit 22. This will produce an anti-lock function in a known manner. In order to prevent the locking of all the wheels on very slippery ground the anti-lock function will over-ride the hill descent control function so that a locked wheel will always be released.

15        The threshold vehicle speed will lie above a vehicle speed corresponding to engine idle speed and may be about 10 kph.

      If, while the vehicle is in hill descent mode, the brake pedal 34 is applied so as to demand a greater amount of  
20    braking than is being provided by the electronic control unit 22, the hydraulic system is such that greater pressure will be applied to the brake and the action of the brake pedal thus cannot be overridden by the electronic control unit to reduce the amount of braking below that produced by  
25    the brake pedal.

If, while the vehicle is in hill descent mode, the control unit 22 detects that the accelerator 30 is depressed to demand greater acceleration or higher speed than is being provided by the electronic control unit 22 at that time, the braking system will be controlled as follows. Over the first part of the travel of the accelerator pedal 30, which may be about a quarter to a third of its full travel, the electronic control unit sets a target vehicle speed proportional to the amount of depression of the accelerator pedal 30. The control unit then controls the brakes 16, 17 so as to try to maintain the vehicle speed at the target speed. If the accelerator pedal is depressed far enough the target speed rises significantly above the speed at which the vehicle is travelling. The hill descent control will therefore not have any effect on the brakes and a smooth change over to normal operation is effected. In this way, the braking control is not suddenly released when the accelerator pedal is depressed.

20 In this way the vehicle 10 can slowly and safely negotiate a steep hill with no need for the driver to use the control pedals 30,34. Once at the bottom of the hill the manually operable switch 32 can be switched off to return to normal operation.

25 The vehicle 10 also includes a loudspeaker 70 which is arranged to emit an audible signal to a driver under the control of the electronic control unit 22. The audible

signal will be emitted from the loudspeaker 70 when the manually operable switch 32 is switched on and the vehicle is put into first gear or reverse from a higher gear and the wheel speed is higher than the set threshold. The  
5 system will then act to slow the vehicle automatically unless over-ridden and the sound from the loudspeaker 70 will provide a warning that the vehicle will be automatically braked.

The vehicle 10 further includes an activation light 72  
10 for the driver which indicates to the driver by different signals the following states: system enabled, system active, system faulty, and, system enabled but suspended (ie. not in first gear or reverse).

By using the valves 66, 68 to reduce pressure when  
15 necessary in a hill descent instead of ABS valves 52 it is made impossible for the hill descent control to reduce  
brake pressure below that brake pressure which may be present due to the driver pressing the brake pedal.

Additional sensors, such as one to three axis  
20 accelerometers (not shown), or an inclinometer 74 may be included in the system. These could be used to determine the steepness of the slope on which the vehicle was travelling, for example by subtracting the acceleration detected by the wheel speed sensors from the total  
25 acceleration detected by the inclinometer. This information could be used to alter the functioning of the hill descent

control. For example the maximum possible deceleration could be reduced if the vehicle is descending a very steep slope. Also the threshold speed could be made dependent upon the steepness of the slope by decreasing with  
5 increasing slope.

It will be appreciated that controlled descent of hills can be provided in a similar manner to that described above, in any system which has a means for increasing braking pressure, as is commonly required for traction  
10 control system, and an anti-lock brake system.



CLAIMS

1. A brake control system for a wheeled vehicle having a plurality of wheels, a plurality of braking means each for braking one of said wheels, and wheel lock detection means for detecting locking of any of said wheels, the system comprising control means which has activated and de-activated states, wherein in its activated state the control means is arranged to apply each braking means to slow the vehicle when a detected vehicle speed is above a predetermined target speed and no wheel locking is detected, but to release any of the braking means if locking of its respective wheel is detected while the detected vehicle speed is above said target speed and to control the rate of change of speed of the vehicle towards the target speed if the vehicle speed is substantially different from the target speed.
2. A system according to Claim 1, wherein the control means is arranged, on entering its activated state, to compare the vehicle speed with the target speed and to control the braking means to bring the vehicle speed towards the target speed.
3. A system according to Claim 1 or Claim 2, wherein the control means is arranged to control the rate of acceleration of the vehicle towards the target speed if

the detected vehicle speed is substantially lower than the target speed.

4. A system as claimed in any one of Claims 1 to 3, wherein the control means is arranged to control the rate of deceleration of the vehicle towards the target speed if the vehicle speed is substantially higher than the target speed.
5. A system according to any one of Claims 1 to 4, wherein said control of the rate of change of speed comprises limiting the rate of change of speed to a predetermined maximum value.
6. A system as claimed in Claim 5, wherein the predetermined maximum value is in the range of about 0.2 to 0.3.
7. A system as claimed in any preceding claim, wherein the activated state is only selectable if the vehicle is in first or reverse gear.
8. A system according to any preceding claim, wherein the control means in its activated state is arranged to be over-ridden by the operation of a braking demand means of the vehicle by a driver to increase the amount of braking over that provided by the control means to slow the vehicle below the target speed if no wheel lock is detected.

9. A system according to any preceding claim, wherein the control means in its activated state is arranged to release the braking means at least partially when the detected vehicle speed is below the target speed.
10. A system according to any preceding claim, wherein the detected vehicle speed is derived from at least one detected wheel speed.
11. A system as claimed in any preceding claim, wherein the control means is arranged to be activated by a manually operable switch.
12. A system according to any preceding claim, wherein the control means is arranged to apply the braking means when the detected vehicle speed is below the target speed if necessary to ensure that the rate of acceleration of the vehicle is less than a limit value.
13. A brake control system for a wheeled vehicle having a plurality of wheels, a plurality of braking means each for braking one of said wheels, and wheel lock detection means for detecting locking of any of said wheels, the system comprising control means which has activated and de-activated states, wherein in its activated state the control means is arranged to apply each braking means to slow the vehicle when a detected vehicle speed is above a predetermined target speed and no wheel locking is detected, but to release any of the braking means if

locking of its respective wheel is detected while the detected vehicle speed is above said target speed, wherein the system further comprises sensing means arranged to determine the steepness of the slope on which the vehicle is travelling and the control means is arranged to make the target speed dependent on said steepness.

14. A system according to Claim 12, wherein the sensing means comprises an inclinometer.
15. A system according to Claim 13, wherein the sensing means further comprises wheel speed sensors and is arranged to determine the steepness of the slope by subtracting an acceleration detected by the wheel speed sensors from a total acceleration detected by the inclinometer.
16. A brake control system substantially as hereinbefore described with reference to the accompanying drawings.
17. A wheeled vehicle having a plurality of wheels, a plurality of braking means each for braking one of said wheels, and wheel lock detection means for detecting locking of any of said wheels, and a brake control system according to any foregoing claim.
18. A wheeled vehicle substantially as hereinbefore described with reference to the accompanying drawings.

**Amendments to the claims have been filed as follows**

1. A brake control system for a wheeled vehicle having a plurality of wheels, a plurality of braking means each for braking one of said wheels, and wheel lock detection means for detecting locking of any of said wheels, the system comprising control means which has activated and de-activated states, wherein in its activated state the control means is arranged to apply each braking means to slow the vehicle when a detected vehicle speed is above a predetermined target speed and no wheel locking is detected, but to release any of the braking means if locking of its respective wheel is detected while the detected vehicle speed is above said target speed and to limit to a predetermined maximum value the rate of acceleration of the vehicle towards the target speed if the detected vehicle speed is substantially lower than the target speed.
2. A system according to Claim 1, wherein the control means is arranged, on entering its activated state, to compare the vehicle speed with the target speed and to control the braking means to bring the vehicle speed towards the target speed.

3. A system as claimed in Claim 1 or 2, wherein the predetermined maximum value is in the range of about 0.2 to 0.3.
4. A system as claimed in any preceding claim, wherein the activated state is only selectable if the vehicle is in first or reverse gear.
5. A system according to any preceding claim, wherein the control means in its activated state is arranged to be over-ridden by the operation of a braking demand means of the vehicle by a driver to increase the amount of braking over that provided by the control means to slow the vehicle below the target speed if no wheel lock is detected.
6. A system according to any preceding claim, wherein the control means in its activated state is arranged to release the braking means at least partially when the detected vehicle speed is below the target speed.
7. A system according to any preceding claim, wherein the detected vehicle speed is derived from at least one detected wheel speed.
8. A system as claimed in any preceding claim, wherein the control means is arranged to be activated by a manually operable switch.

9. A system according to any preceding claim, wherein the control means is arranged to apply the braking means when the detected vehicle speed is below the target speed if necessary to ensure that the rate of acceleration of the vehicle is less than said predetermined maximum value.
10. A brake control system according to any foregoing claim and substantially as hereinbefore described with reference to the accompanying drawings.
11. A wheeled vehicle having a plurality of wheels, a plurality of braking means each for braking one of said wheels, and wheel lock detection means for detecting locking of any of said wheels, and a brake control system according to any foregoing claim.
12. A wheeled vehicle according to Claim 11 and substantially as hereinbefore described with reference to the accompanying drawings.



Application No: GB 9805731.8  
Claims searched: 1 - 18

Examiner: P M Weller  
Date of search: 21 April 1998

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F2F (FC)

Int Cl (Ed.6): B60T 8/00 8/24 8/32 8/34 8/44 8/48

Other: NONE

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | Relevant to claims |
|----------|---|--------------------|
| A        | DE 2419242 A1 KNORR-BREMSE                |                    |
| A        | JP 61102336 A MAZDA                       |                    |

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